FIELD OF THE INVENTION

The invention relates to an apparatus for generating surface pressure, in particular in an injection molding machine, having a stationary carrier platen and a clamping platen which can be moved in relation to said carrier platen and locked in a working position and which, on its side facing the carrier platen, has a closing platen that can be moved out electromechanically, material to be pressed or tools to be clamped being disposed between said closure platen and the carrier platen.

Generating a surface pressure in this way is known in principle from DE 43 36 572 C1. In this case, the clamping platen and closing platen of an injection molding machine are moved relatively quickly by a first moving mechanism, and then the clamping platen is locked in the working position. The injection molding operation is started and, in order to cushion the forces originating from the plastics flow front, the closing platen is moved out by an alternating magnetic field being applied to a positively magnetostrictive material.

However, an electromechanical movement acting on this principle has the disadvantage that relatively high current intensities are needed. In addition, a permanent current has to be maintained, even in the stationary state.

It is an object of the invention to construct an apparatus for generating surface pressure of the type mentioned at the beginning in such a way that a rapid and

powerful electromechanical movement is achieved in the technically simplest possible way.

According to the invention, this object is achieved by the compressive force of the closing platen and the action of moving it at the working point being implemented by piezoelectric actuators.

These components have been tried and tested for a long time for various tasks in engineering, but have neither been proposed nor used for moving closing platens in apparatus for generating surface pressure.

A first advantageous embodiment of the invention is characterized by the fact that the piezoelectric actuators are distributed as desired, preferably in matrix fashion, over the area between clamping platen and closing platen. This results in an arrangement of the actuators which can be implemented simply in technical terms and is comprehensible. However, it is also possible for the piezoelectric actuators to be distributed over the area between clamping platen and closing platen in accordance with the desired force distribution (hardware implementation of the force distribution). The manner in which such an arrangement is to be made can be determined analytically or by means of trials. A second possibility of corresponding with a force distribution consists in actuating the piezoelectric actuators differently (software implementation of the force distribution).

The fact that, in the event of dynamic behavior of the material to be pressed or the tools to be clamped, the piezoelectric actuators can likewise be triggered dynamically, matched to said behavior, means that the response behavior can be configured so as not to damage the machine.

For the case in which relatively long distances have to be bridged with the aid of the piezoelectric actuators, it proves to be advantageous if the closing platen can also be locked in at least one intermediate position which makes up a piezoelectric stroke and from which the clamping platen can subsequently be guided, the latter then being locked and the closing platen being moved out by a further piezoelectric stroke.

The piezoelectric actuators can be produced with any desired geometry, preferably cube-like, in accordance with the production possibilities, and can therefore be matched relatively easily to all machine requirements.

It is certainly possible for additional piezoelectric sensors to be provided between closing platen and clamping platen, in order that pressure measurements can be performed completely independently of the piezoelectric actuators. However, it is also possible that, during operation, a subset of the piezoelectric actuators can be used as piezoelectric sensors and, likewise, it is also possible that, during operation, piezoelectric actuators can be used briefly as piezoelectric sensors. The two last-named alternatives have the advantage that double use of the piezoelectric actuators is made, by the latter being used as piezoelectric sensors.

An exemplary embodiment of the invention is illustrated in the drawing and will be explained in more detail below. In the drawing:

FIG. 1 shows elements of a plastic injection molding machine, and

FIG. 2 shows a possible arrangement of piezoelectric actuators.

In the illustration of FIG. 1, elements of a plastic injection molding machine which are essential to the present invention are shown. This machine is shown in the extended state, in which two half molds FH1 and FH2 are spaced apart from each other, so that a finished molding, not shown for reasons of clarity, can be removed from the machine. The half mold FH1, whose internal contour is indicated by a dashed line, is fixed to a stationary carrier platen TP. From the latter, spars extend from each corner, of which only the spars H1 and H2 can be seen in the illustration. On these spars, for example the spars H1 and H2, a clamping platen AP can be moved bidirectionally and relatively quickly by a drive, which is not shown for reasons of clarity, this movement being indicated by a double arrow. A closing platen SP is also arranged, together with the clamping platen AP, in a sliding manner on the spars, for example the spars H1 and H2, piezoelectric actuators being disposed between the clamping platen AP and the closing platen SP, of which only the piezoelectric actuators P1 to P7 can be seen in the illustration according to FIG. 1. In order to

protect the piezoelectric actuators against inadmissible tensile stresses, they are mounted between the closing platen SP and the clamping platen AP so as to be prestressed mechanically.

When a workpiece is to be created, the clamping platen AP and closing platen SP are moved in such a way that the half molds FH1 and FH2 butt against each other. The clamping platen AP is then locked in its position in a force-fitting and/or form-fitting manner with respect to the spars, for example the spars H1 and H2, by aids which are likewise not illustrated for reasons of clarity, and the thermoplastic material can be injected into the space between the half molds FH1 and FH2. However, in order to compensate for mechanical deformations in the overall system, the flow pressure of the injected material must be opposed by the half mold FH2 with a deflection defined by the mechanics of the machine, which is carried out with the aid of the piezoelectric actuators, which are actuated electrically for this purpose. This activation can in this case be carried out simultaneously for all the actuators or else by means of an adapted, chronologically staggered reaction of the piezoelectric actuators in accordance with the propagation properties of the plastic between the half molds FH1 and FH2.

The fact that the piezoelectric actuators are disposed distributed over the area of the closing platen SP can be taken from the illustration of FIG. 2, which shows that, in addition to one row of piezoelectric actuators, still further rows of piezoelectric

actuators can be provided. The number and the geometry of the piezoelectric actuators depends on the required closing force and the expansions of the apparatus for generating surface pressure which have to be compensated for. The strictly matrix-like arrangement preferably shown here can certainly be varied, however, in accordance with the machine requirements, and can be selected in as desired. To this end, the mechanical behavior of the system has to be determined for the tools and machines used.

It is essential to the present invention that such a determination of the mechanical relationships can be carried out, during operation, by in each case a subset of the piezoelectric actuators being used as piezoelectric sensors. These actuators do not then have a control voltage applied to them which triggers a piezoelectric stroke, instead the generator behavior of the actuators is used, specifically that under the influence of a force, a voltage can be tapped off across the actuators. In principle, it is also conceivable for all the actuators in each case to be used briefly as sensors, it then being necessary, of course, to take into consideration the tolerable movements of the available masses for this purpose. As an alternative or as an addition to this, however, it would certainly be possible for further piezoceramics, used only as sensors, to be disposed between the piezoelectric actuators and, on account of their smaller dimensions, still to find space there.

For the case in which the distances which can be triggered by the piezoelectric actuators are too small for the machine behavior, the closing platen SP can be fixed in a force-fitting and/or form-fitting manner, just like the clamping platen AP, by means of a mechanism, likewise not shown for reasons of clarity. Initially, the closure platen SP will not be locked and, starting from a locked clamping platen AP, a piezoelectric stroke will be carried out. The closing platen SP will then be locked and then the unlocked clamping platen AP will subsequently be guided and locked, and then the closure platen SP will be released and a further piezoelectric stroke brought about.

Apparatus for generating surface pressure are understood to mean not only injection molding machines but, for example, also other pressing and compressing machines in production engineering.